LOW TEMPERATURE EVALUATION OF THE TC170 CMOS CURRENT-MODE PWM CONTROLLER

Test Report

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February 25, 2002

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Background

The Microchip Technology TC170 is a current-mode pulse-width-modulation controller based on CMOS technology. It features fast rise/fall times with dual push-pull outputs [1]. The device requires low supply current with an input voltage range from 8 to 16 V. The dual totem-pole CMOS outputs can drive power MOSFETS or bipolar transistors. The device is capable of high frequency switching (200 kHz) and is specified for operation in the temperature range of 0 °C to +70 °C. Other features include double-pulse suppression, soft-start operation, programmable current limit, undervoltage lockout, and excellent line and load regulation. Two or more of these controllers can be slaved together for parallel operation. The circuits can operate from a master TC170 internal oscillator or an external system oscillator [1]. CMOS-based devices typically perform well at low temperatures. This device was, therefore, selected for evaluation for potential use in the development of a low temperature dc/dc converter module.

Test Setup

A circuit board, populated with the TC170 chip, a transistor, and few passive components, was designed and built for evaluation in the temperature range of +20 °C to –185 °C. The circuit layout used in this investigation is shown in Figure 1. The device was characterized at test temperatures of 20, 0, -25, -50, -75, -100, -125, -150, -175 and -185 °C in a liquid nitrogen cooled environmental chamber. At each test temperature, the device was allowed to soak for 15 minutes before measurements were made. The device performance in terms of its switching frequency and duty cycle control was evaluated as a function of temperature. The switching frequency was set to about 30 kHz through selected external resistive and capacitive components. The duty cycle of the two outputs was controlled by varying the external voltage control level applied to the differential input of the error amplifier.

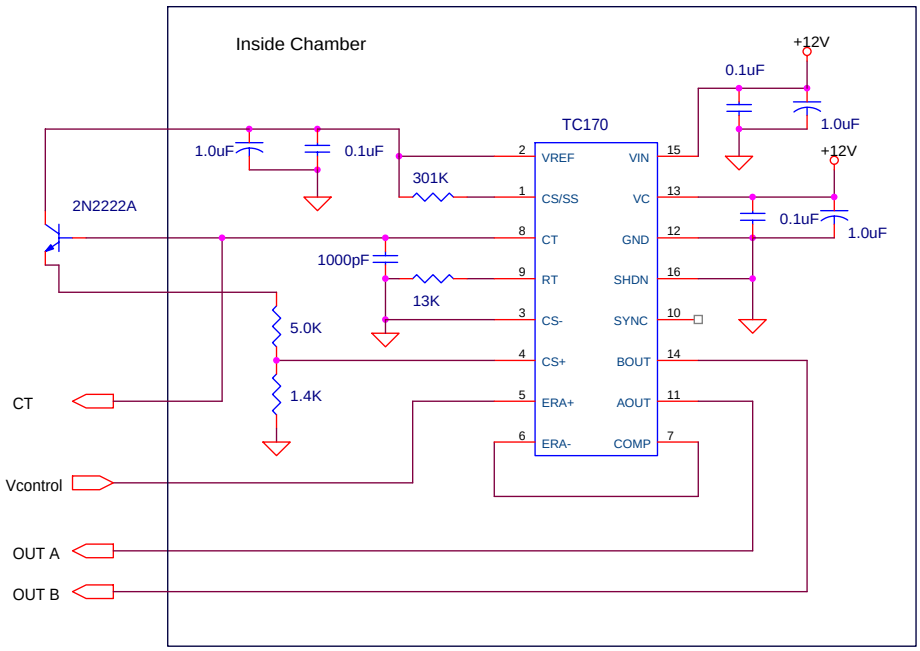

Figure 1. Test setup for the TC170.

Results and Discussion

Testing of the device was initially performed at 20 °C after which measurements were taken at lower temperatures with an increment of 25 °C. At each test temperature, the device was allowed to soak for 15 minutes before measurements were made. Performance of the device as a function of temperature is depicted in Table I. Listed are the source current (Is), minimum and maximum duty cycle (D), internal reference voltage (Vref), and the switching frequency at the different test temperatures. The data, which is listed in the last row of Table II, represents measured parameters obtained at room temperature after completion of the thermal cycling. Throughout these tests, an input of 12 V was supplied to the device and a control voltage between 2 and 4 V was used to vary the duty cycle.

It can be clearly seen that while the internal reference voltage remains, in general, steady throughout the entire test temperature range, the frequency undergoes a slight increase as temperature is decreased. The duty cycle exhibits similar behavior to that of the frequency with change in temperature. This increase in the duty cycle is more apparent at its maximum. Unlike the frequency and the duty cycle, the supply current changes considerably with temperature. It can be seen that the current increases as the temperature is decreased. At the extreme temperature of –185 °C, for example, the supply current amounts to about 5 mA; a value that is more than double its room temperature counterpart. These temperature-induced changes in the device characteristics tend to be transitory as all investigated parameters regain their original values after the temperature stress has been removed, as indicated in Table I.

Table I. TC170 device characteristics at various temperatures.

Temperature (°C)	**Is (mA)**	**Dmin (%)**	**Dmax (%)**	**Vref (V)**	**Freq (kHz)**
20	2.4	21.7	43.3	5.00	29.2
0	2.6	21.7	44.2	5.00	30.0
-25	2.8	21.6	45.0	5.00	30.7
-50	3.1	21.5	45.8	5.02	31.4
-75	3.5	21.9	46.5	5.03	32.1
-100	3.9	21.6	47.0	5.04	32.7
-125	4.4	21.1	47.5	5.07	33.2
-150	4.9	22.0	47.8	5.00	34.0
-175	5.4	22.8	48	5.08	33.6
-185	5.1	22.6	47.9	5.02	33.6
20	2.4	22.0	43.6	5.00	29.6

Waveforms of the device reference voltage, oscillator, and the two modulated output voltages, which were recorded with the duty cycle at its maximum, are shown in Figure 2 at test temperature of 25 °C. These waveforms were also recorded at –185 °C under the same conditions and are depicted in Figure 3. It is quite evident that the device undergoes very little changes in its operational behavior as a result of the low temperature exposure.

Conclusion

The Microchip Technology TC170 CMOS current-mode PWM controller, which is a commercial-grade device rated for 0 to 70 °C operation, has been evaluated for potential use in low temperature applications. The device was characterized in terms of its switching frequency, internal reference voltage, and duty cycle control in the temperature range of 20 °C to -185 °C. Although very slight changes occur in some of these parameters, little effect on the device overall performance is observed as a result of exposure to low temperature. The results of this preliminary work indicate that the device has the potential of utilization in circuits and systems designed for operation in low temperature applications. Further testing is needed, however, to establish operational performance and reliability of these devices under long-term temperature exposure and thermal cycling.

References

1. TC170 CMOS Current-Mode PWM Data Sheet DS21395A, Microchip Technology, Inc.

Acknowledgments

This work was performed under the NASA Glenn Research Center GESS Contract # NAS3-00145. Support was also provided from the NASA Electronic Parts and Packaging (NEPP) Program, EPAR Task “Electronics for Extreme Environments”.

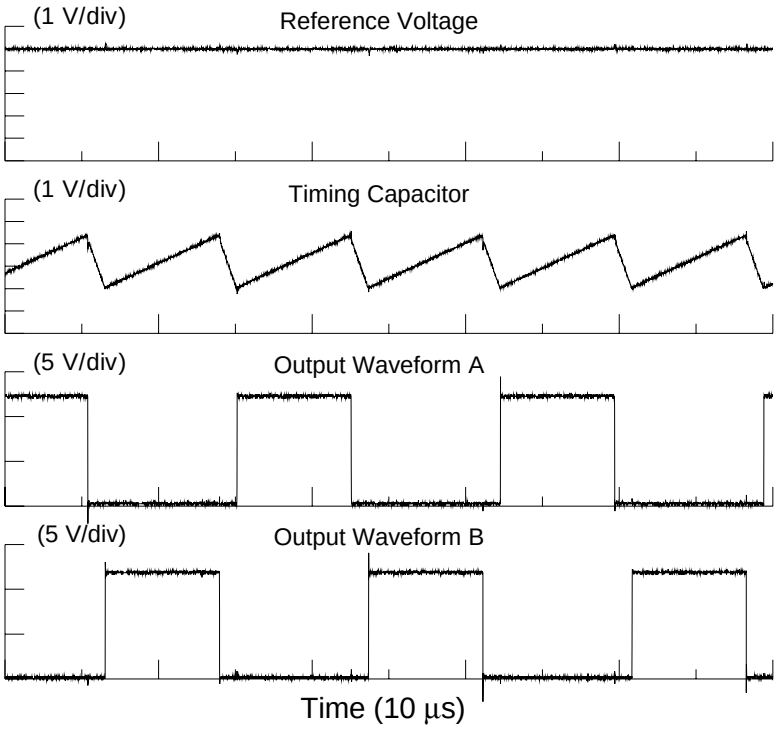

Figure 2. Waveforms of the TC170 controller at 20 °C.

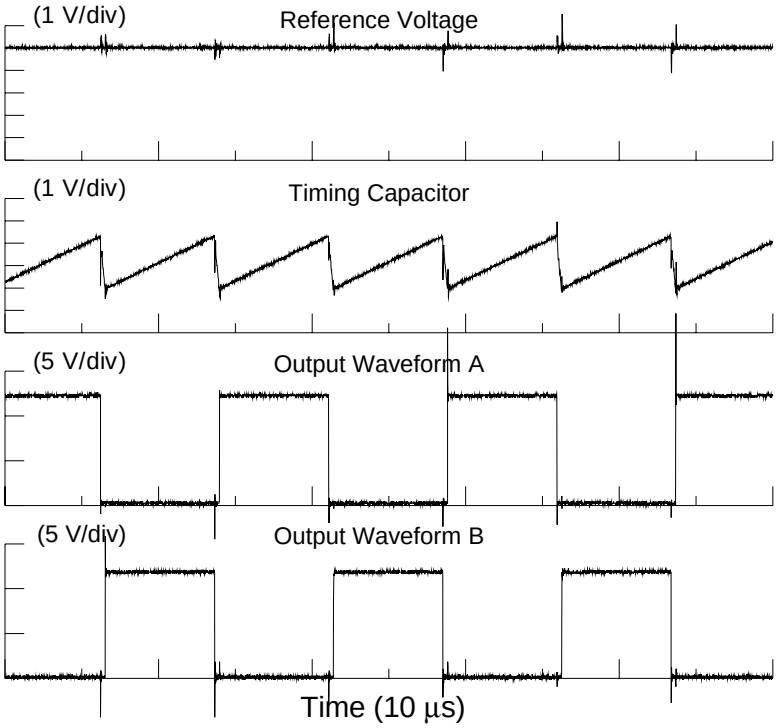

Figure 3. Waveforms of the TC170 controller at -185 °C.